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PERFORMANCE ANALYSIS OF DIESEL ENGINE USING BIODIESEL WITH THE INFLUENCE OF DIMETHYL ETHER BLEND

VENKATESH. R[1], PRABHAHAR. M[2] & SANJAY SINGH[3]

[1,3]Research Scholar, Department of Mechanical Engineering, Vinayaka Mission Kirupananda Variyar Engineering College, Vinayaka Mission's Research Foundation, Tamil Nadu, India

[2]Professor, Department of Mechanical Engineering, Aarupadai Veedu Institute of Technology, Vinayaka Mission's Research Foundation, Tamil Nadu, India

ABSTRACT

Mono esters and Dimethyl ether are the two different promising alternative fuels for CI engine. In this study, the various ratios of Di Methyl Ether (DME) blended with 20% Calophyllum Inophyllum Methyl Ester (CIME20) blends have been examined on working characteristics of diesel engine under various loads. In this work, the DME is mixed with different ratios like 10% and 15% (vol. %) with 20% CIME blend. The experimental results indicate that DME improve the brake thermal efficiency (BTE) and decrease nitrogen oxide (NO), carbon monoxide (CO), and smoke emissions, while hydrocarbon (HC) and brake-specific fuel consumption (BSFC) emissions are increased. It is concluded that the 15% of DME blend with CIME20 gave the improvement in performance and decrease the gas emissions of the engine that is utilized partially to replace the diesel usage in diesel engine.

KEYWORDS: Diesel Engine, Calophyllum Inophyllum methyl Ester, Dimethyl ether, Performance & Emissions

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Original Article

1. INTRODUCTION

Diesel engines are majorly utilized in passenger cars, goods vehicles, power plants and agricultural purpose and propel the ships due to its fuel consumption and high thermal efficiency. The merits of diesel engine are that it emits less HC and CO emissions because it burns at lean mixture operations. The demerits are that it has high nitrogen oxide emissions and particulate matter. Hence, it cannot be assured about the progressively more stringent emission rules [1]. Due to increase in environmental degradation of automobile pollution and depletion of fossil fuel resources, it is necessary to identify an alternative fuel for internal combustion(IC) engine [2].

Now a days there has been an increase in interest towards the mono esters derived from animal fat or vegetable oils by tranesterification method referred to as biodiesel used in CI engine due to the reasons that mono esters are oxygenated and sulphur free and it produces less exhaust emissions, except NO emissions. Biodiesel is receiving attention as a fuel for diesel engines due to their characteristics that are similar to diesel. Biodiesels are non toxic, biodegradable and renewable in nature and it may be utilized in engines without alterations [3, 4].

The numerous research works have been accepted out to examine the effect of diesel -biodiesel blends on the working characteristics of the engines [5, 6]. It is noted that use of biodiesel in engines produced less brake power, and higher BSFC because of high viscosity and density compared to diesel. Many researchers have made challenges to lesser the NO_x emission using oxygenated additives. Addition of oxygenated additives to liquid fuels improves its oxidation property due its O_2 present in the fuel and high latent heat of oxygenated fuels [7]. In [8,9]

utilized the diethyl ether as an additive (Oxygenated) for diesel-biodiesel blends fuel and noted an important enhancement in NO_x emission characteristics. There are stringent discharge standards on automotives fumes outflows, particularly on nitrogen oxides (NOx) and smoke emanations [10]. It is found through assessment of the exhibition of a diesel Engine with lemon grass oil mix with various compression pressures, the fumes emission CO and HC were diminished [11].

2. MATERIALS AND METHODS

2.1 Preparation of Calophyllum Inophyllum Biodiesel

In this work, the Calophyllum Inophyllum methyl ester (CIME) has been selected as fuel for diesel engine. It is prepared from raw Calophyllum Inophyllum oil by tranesterification chemical reaction with methyl alcohol in the presence of a catalyst. The one litre of CI oil was taken in beaker and 200ml of methanol with 8gm of KOH was dissolved in the methanol to prepare the methoxide solution. Then, this solution was added with CI oil and heated up to 65^{o}C with the help hot plate with constant stirring, and then this was allowed to cool for 8hours. After settling of this solution, mono esters were formed at top and glycerin was obtained as the products which are in the bottom of the flask. The mono ester was separated and washed and dried to remove the traces of methanol. Finally, the product obtained was CI methyl ester (CIME) which is called as biodiesel. The properties of CIME and diesel are illustrated in Table 1. DME is also referred as methoxy methane of an organic compound with the formula CH3OCH3. DME is used in present engine structure which is renewable energy source and does not release sulfur. This will decay anareobically and aerobically with natural source of fuel [9, 10].

2.2 Experimental Set up

A Kirloskar diesel engine was employed to carry out test and it is connected with the dynamometer with coupling as shown in Figure 1. The Engine technical details are illustrated in table 2. Two separate tanks are utilized for fuels and fuel fed into the engine was measured by burette and stop watch method. The tail pipe emissions were calculated by smoke meter and gas analyzer. The cylinder pressure was calculated with piezo electric pressure transducer and a crank angle encoder. All fuel properties are listed in Table 1.

Table 1: Fuel Properties

Properties	ASTM Standard	Diesel	CIME	DME
Density (kg/m^3)	D127	830	878	667
K. Viscosity @ 40^{o}C (cSt)	D2217	2.83	3.45	0.184 @20^{o}C
Calorific value (MJ/kg)	D4809	43	36.4	27.6
Flash point (^{o}C)	D93	56	165	-42
Cetane Number	D6890	46	59.5	>55
Oxygen (%) by wt	D943	-	11.8	34.8
Latent heat (kJ/kg)	D2015	250	-	420

Table 2: Test Engine Specifications

Make & Type	KIrloskar,TV-1, Vertical, 4 Stroke, Single cylinder
Rated power	4.4kW
Bore X Stroke	87.5x110 (mm)
Displacement	661cc
Nozzle opening pressure	200bar
Injection timing	23°bTDC
Compression ratio	17.5:1
Gas Analyzer	AVL 444 Di gas analyzer
Smoke meter	AVL-437C

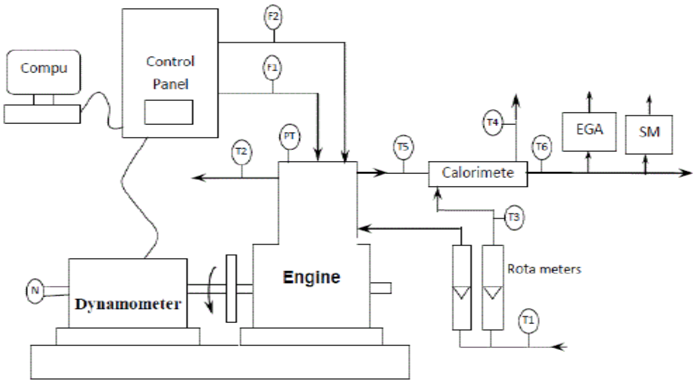

Figure 1: Layout of the Test Engine.

3. RESULTS AND DISCUSSION

The engine test was carried out in a diesel engine using diesel and CIBD20 at different injection pressures. The measured values are analyzed and discussed in this section.

3.1 BTE

Difference in BTE with BP for diesel and CIME-DME blends is represented in Figure 2. BTE for biodiesel is lesser than diesel at all loads because of its high viscosity results poor atomization and lower energy content of the biodiesel. The DME addition with CIME20 considerably raises the BTE due to improved combustion of the biodiesel by adding DME, which acts as a cetane enhancer. The higher BTE obtained for CIME20 with the addition of DME10% (CIME20DME10) is 29.7% which is 1.2% higher than CIME20 at maximum load.

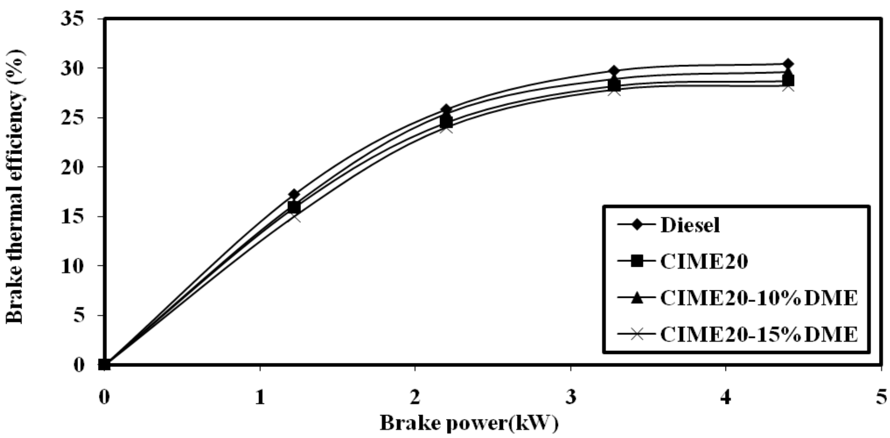

Figure 2: BTE versus BP.

3.2 Brake Specific Fuel Consumption

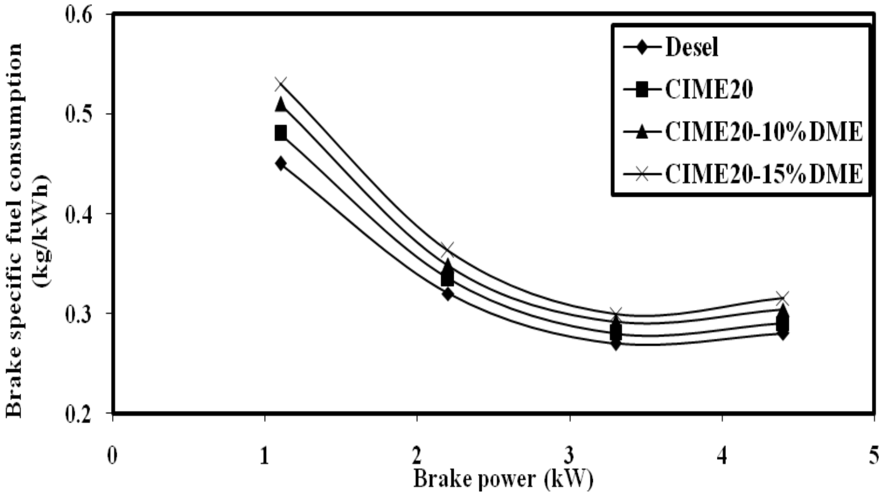

Figure 3: BSFC versus BP.

BSFC difference with BP for diesel and CIME20 with DME bends is depicted in Figure 3. BSFC of biodiesel is always elevated than diesel because of its higher viscosity and its lower energy contents results to the reduced combustion and thus increases the fuel consumption (Devarajan et al., 2017). BSFC diminished with rising DME mix together, which is down to elevated and oxygen higher cetane number content that enhance the complete combustion. The lowest BSFC achieved for CIME20DME10 which is lower than CIME20. BSFC for CIME20 is 0.295kg/kWh and for CIME20DME10 are 0.285kg/kWh at full load.

3.3 Carbon Monoxide Emission

The change of CO emissions for diesel and CIME20 with DME blends is illustrated in Figure 4. At all loads, CO emissions for monoesters are lesser than diesel, because of its inherent oxygen in the structure of the biodiesel, which enhances oxidation of fuels and results in lower the CO emissions. Especially, addition of DME with CIME20 decreases the CO, because of its higher cetane number, which improves combustion of the blend. CO emission for CIME20 is 0.075% and for CIME20DME10 is 0.06% and for CIME20DME15 is 0.054% at full load.

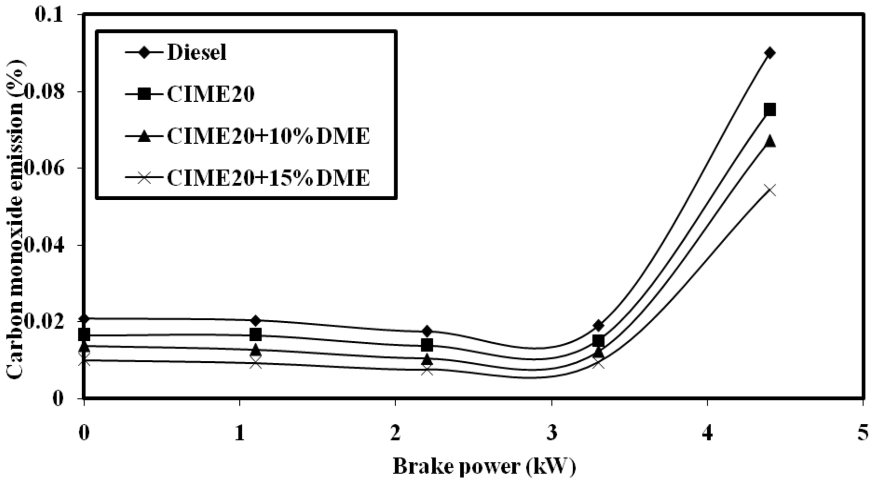

Figure 4 - Carbon Monoxide Emission versus BP

3.4 Hydrocarbon Emission

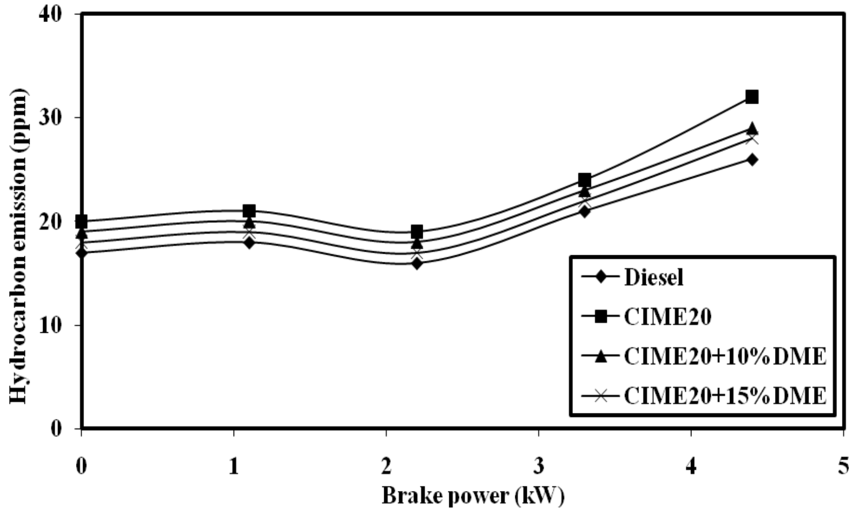

Figure 5: Hydrocarbon Emission versus BP.

The variation of HC emissions for diesel and CIME20 with DME blends with BP is presented in Figure 6. At all loads, HC emissions for monoester fuels are lesser than diesel. This is because of monoester has elevated oxygen substance in it; this improves oxidation reaction, and effect decreases the HC. Addition of DME with monoesters especially decreases the HC and the further decreases with an increase in the mass DME with CIME20. This is attributed to the lower viscosity and higher cetane number that enhances the combustion of the blend. HC emission for CIME20 is 32ppm, for CIME20DME10 is 29ppm and for CIME20DME15 is 28ppm at full load.

3.5 Nitrogen Oxide Emiision

Variation of NO emissions with BP for diesel and biodiesel with DME blends is represented in figure 6. NO emissions for methyl esters is always higher than diesel. This is owing to O_2 present in biodiesel produces higher combustion temperature. Especially, addition of DME with CIME20 decreases the NO emission. Then lessening is proportionally increases with the raise in DME ratio with CIME20. NO emission for CIME20 is 1037ppm, for CIME20DME10 is 866ppm and for CIME20DME15 is 796ppm at full load.

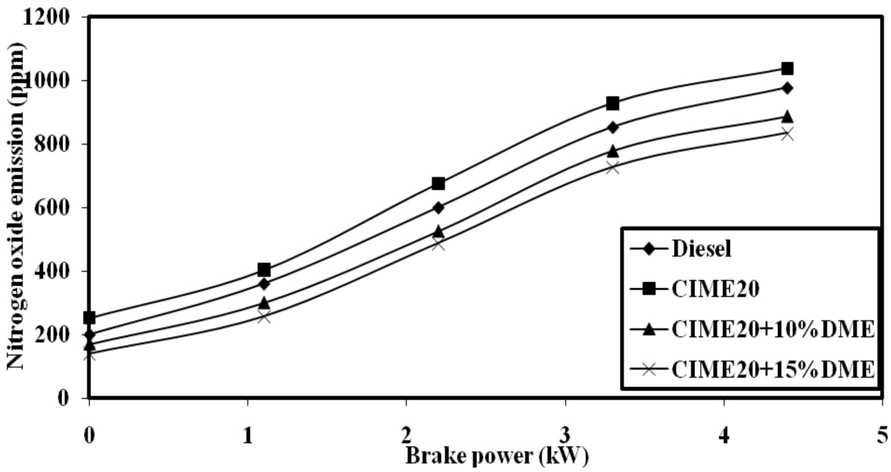

Figure 6: NO Emissions versus BP

3.6 Smoke Opacity

The change of smoke opacity for diesel DME blends with CIME20 is depicted in Figure 7. Smoke emissions for methyl esters are lesser than diesel at all loads owing to O_2 present in the esters, which promotes the oxidation of fuel and results in lower opacity. Addition of DME methyl ester especially lowers the opacity emission and further decrease will proportionally increase the DME blend due to rise in its cetane number and its lower viscosity which result in enhanced combustion and lowers the smoke emissions. Smoke opacity of CIME20 is 25%, for CIME20DME10, it is 22% and CIME20DME15, it is 20% at full load.

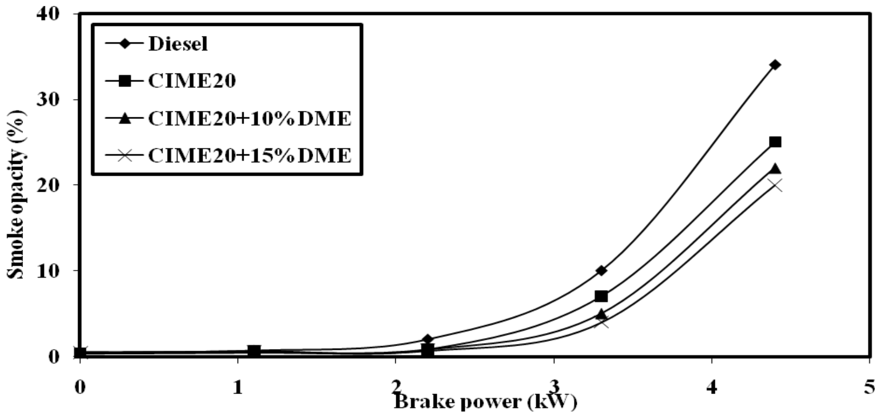

Figure 7: Smoke Opacity versus BP.

4. CONCLUSIONS

From the research findings, the important conclusions are derived as follows:

- The BTE of CIME20 is 1.7% lower than diesel but the addition of DME at 10% volume enhances the BTE by 0.9% when compared to CIBD20 at maximum brake power. The BSFC of CIME20 with the addition of DME lowers the SFC when compared with CIME20.
- CO emission of CIME20 with the addition of 10% and 20% DME decreased by 20% and 42% respectively. Similarly, the HC emissions were also decreasing with an increase in blend of DME with CIME20 at BP.
- NO emission of CIME20 with the addition of DME decreased by 15- 3% when compared to CIME20 at maximum BP.
- Smoke was lesser by 25% by totaling DME 15% to CIME20 when compared to CIME20 at maximum BP due to improved fuel mixing with air during combustion.

REFERENCES

1. *Rajan, K., and K. R. Senthil Kumar. "Performance and emissions characteristics of a diesel engine with internal jet piston using biodiesel." International Journal of Environmental Studies 67.4 (2010): 557-566.*
2. *Senthil, Kumar Srinivasan, Krishnan Purushothaman, and Kuppusamy Rajan. "Performance analysis of compression ignition engine using rubber seed oil methyl ester blend with the effect of various injection pressures." Thermal Science 20.suppl. 4 (2016): 1083-1090.*

3. *Rajan, K., et al. "Impact of nozzle opening pressure on the performance and emission behaviours of the CI engine using yellow oleander biodiesel." International Journal of Ambient Energy (2019): 1-7.*
4. *Srikanth, D., MVS Murali Krishna, and P. Usha Sri. "Impact of Injection Timing and Injection Pressure on Performance Parameters and Combustion Characteristics of High Grade Semi Adiabatic Diesel Engine with Cotton Seed Biodiesel." International Journal of Mechanical and Production Engineering Research and Development (IJMPERD), 6 (1), 1 14 (2018).*
5. *Annamalai, Ravichandran, Rajan Kuppusamy, and Ramachandran Senthilkumar Krishnan. "Effect of piston bowl geometry and different injection pressure on the performance, emission and combustion characteristics of diesel engine using biodiesel blend." Thermal Science 22.3 (2018): 1445-1456.*
6. *Manickam, A. R., et al. "Experimental analysis of a diesel engine fuelled with biodiesel blend using di-ethyl ether as fuel additives." International Journal of Engineering and Technology 6.5 (2014): 2412-2420.*
7. *Mundhe, Raju G. "Renewable Energy Source Algae Biodiesel as Alternative Fuel." (2017).*
8. *Rajan, K., M. Prabhahar, and K. R. Senthilkumar. "Experimental studies on the performance, emission and combustion characteristics of a biodiesel-fuelled (Pongamia methyl ester) diesel engine with diethyl ether as an oxygenated fuel additive." International Journal of Ambient Energy 37.5 (2016): 439-445.*
9. *Manickam, A. R., et al. "Reduction of Exhaust Emissions on a Biodiesel fuelled Diesel Engine with the Effect of Oxygenated Additives." International Journal of Engineering and Technology (IJET) 6 (2014): 2406-2411.*
10. *Joy, Nivin, Devarajan Yuvarajan, and Nagappan Beemkumar. "Performance evaluation and emission characteristics of biodiesel-ignition enhancer blends propelled in a research diesel engine." International Journal of Green Energy 16.4 (2019): 277-283.*
11. *Venu, Harish, and Venkataramanan Madhavan. "Effect of Al2O3 nanoparticles in biodiesel-diesel-ethanol blends at various injection strategies: Performance, combustion and emission characteristics." Fuel 186 (2016): 176-189.*
12. *Rao, P. Venkateswara, and BV Appa Rao. "Heat release rate, performance and vibration analysis of diesel engine operating with biodiesel-Triacetin additive blend fuels." International Journal of Automobile Engineering Research and Development 8.2 (2018): 1-12.*
13. *S.Prakash, M.Prabhahar and M.Saravana Kumar "Experimental analysis of diesel engine behaviours using biodiesel with different exhaust gas recirculation rates" International Journal of Ambient Energy, ISSN: 0143-0750 (Print) 2162-8246 (Online), https://doi.org/10.1080/01430750.2020.1712251.*
14. *M.Saravana Kumar, M.Prabhahar and S.Prakash "Effect on performance and exhaust emission using lemongrass*
15. *biodiesel as fuel on VCR direct injection diesel engine" International Journal of Mechanical and Production, Engineering Research and Development (IJMPERD), ISSN (P): 2249–6890; ISSN (E): 2249–8001, Vol. 9, Issue 6, Dec 2019, 951–964*

AUTHOR'S PROFILE

Mr. R Venkatesh is currently working as a teaching faculty and research scholar in the Department of Mechanical Engineering of Vinayaka Mission's Kirupananda Variyar Engineering College, Periyaseeragapadi, Salem, A constituent

college of Vinayaka Mission's Research Foundation, Deemed to be University, Salem, Tamil Nadu. He has completed his B.E. in Mechanical Engineering from Kongu Engineering College, Perundurai, Erode and M.E in Computer Aided Design from Govt. College of Engineering Salem, Anna University, Chennai. His area of interest is low heat rejection in automotive engines and alternate fuel. He has already published 05 papers in international journals.

Dr. M. Prabhahar obtained his Under Graduation in BE Mechanical Engineering at Jayamatha Engineering College, Nagercoil. He completed his his Post Graduation from Mepco Schlenk Engineering College, Sivakasi. He completed his Research work and got his Ph.D. Degree from St. Peters University, Chennai. At the time of submission of his thesis, he had fifteen publications to his credit. He acquired his Ph.D. for his research work in the area of IC Engines performance and Emission Control using alternate fuels. His assiduous and prolific research work has earned him very good reputation in the field of bio alternate fuels. He has 85 citations in the International Journals including Springer, Taylor and Francis and IEEE proceedings. He is a member of several technical executive committees on National and International conferences and potential reviewer of several journals which in turn reviewing minimum four papers per month. His research paper "Modeling and construction of bio diesel processor", has been selected for the cover note article for the Global Journal of Research in Engineering, USA. He has to his credit, more than 40 publications in reputed journals and has h-index as 5. He is also extending his meritorious service of being referee of many reputed journals. He is currently working as Professor in Department of Mechanical Engineering, Aarupadai Veedu Institute of Technology, Paiyanoor, Chennai.

Mr. Sanjay Singh is currently working as a teaching faculty and research scholar in the Department of Mechanical Engineering of Vinayaka Mission's Kirupananda Variyar Engineering College, Periyaseeragapadi, Salem, A constituent college of Vinayaka Mission's Research Foundation, Deemed to be University, Salem, Tamil Nadu. He has completed his AMIE in Mechanical Engineering from The Instituion of Engineers (India), Kolkata and M.E. in Automation and Robotics from University College of Engineering, Osmania University, Hyderabad. His areas of interest is Jet Propulsion and is doing his research work on alternate fuel particularly in the methyl ester produced from the Chlorella microalgae and its suitability for use in aviation and automobiles. He has already published four papers in International Journals.